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WienerFilter

Introduction

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Wiener filter is a estimation method proposed by N Robert Wiener during the 1940s and published in 1949. The motivation for this algorithm is to improve the energy estimation in the online processing of signals from E Tilecal cells (high occupancy channels) inside the Read-Out Drivers (RODs) modules.

Note: The efficiency of Wiener Filter to estimate energy in E TileCal cells is currently being studied and its implementation is being considered for Phase-II.

Wiener Filter algorithm description

The bases of this algorithm are described by S. Haykin in ISBN 978-0-132-67145-3 (2013) 108 - 140. The wiener filter uses knowledge of the statistical properties of both the signal and the noise to reconstruct an optimal estimate of the signal from a noisy data stream.

The idea is to minimize the expected value of the squared of the error:

$$J = E[(\hat{A} - A)^2]$$

Let R denote the N-by-N correlation matrix of the inputs $u(n), u(n-1), \dots, u(n-N+1)$:

$$R = E[u(n)u^H(n)]$$

Correspondingly, p is denoted as N-by-1 cross-correlation vector between the inputs of the filter and the desired response $d(n)$:

$$p = E[u(n)d(n)]$$

The wiener equation can be rewrite in the compact matrix form:

The amplitude estimation is given by:

$$\hat{A} = \sum_{i=1}^N s_i w_i$$

Inclusion of an additional weight in the optimization procedure:

In order to absorb bias (mean of the error) an element w_{N+1} is added to each input signal, as last element.

This way, the amplitude estimation is given by:

$$\hat{A} = \sum_{i=1}^N s_i w_i + w_{N+1}$$

Where, μ corresponds to the bias that is subtracted in each estimation

Documentation

Links of all talks done related to Wiener Filter applied in E TileCal Cells:

- Energy Reconstruction studies for HL-LHC (E4 Cells case):

<https://indico.cern.ch/event/703027/contributions/2898945/attachments/1602005/2540143/EneReco2.pdf>

<https://indico.cern.ch/event/702998/contributions/2883660/attachments/1594665/2525136/EneRecoSimulationMeeting>

<https://indico.cern.ch/event/711640/contributions/2922427/attachments/1611342/2558719/EneRecoSimulationMeeting>

<https://indico.cern.ch/event/713504/contributions/2931428/attachments/1615227/2567383/EneRecoSimulationMeeting>

- Wiener Filter and OF2 performancy studies for HL-LHC (E4 Cells case):

<https://indico.cern.ch/event/722757/contributions/2972311/attachments/1633941/2606130/EneRecoSimulationMeeting>

- Detailed description of Wiener filter method

<https://indico.cern.ch/event/731568/contributions/3016241/attachments/1655459/2650141/EneRecoSimulationMeeting>

- Wiener Filter performance studies for HL-LHC considering the LHC bunch train scheme

<https://indico.cern.ch/event/738604/contributions/3048268/attachments/1672581/2683714/EneRecoSimulationMeeting>

- Description of Wiener filter method and first results of its performance using real data

<https://indico.cern.ch/event/730841/contributions/3028107/attachments/1663897/2666695/TileWeekPerformance.pdf>

- Comparison of the OF2, optimised Wiener filter, a generalised version of the Wiener filter performance

<https://indico.cern.ch/event/746578/contributions/3087892/attachments/1693468/2725242/EneRecoSimulationMeeting>

- General description of the studies and a compilation of results acquired until september 2018

<https://indico.cern.ch/event/759687/contributions/3151179/attachments/1724051/2784230/EneRecoSimulationMeeting>

- Wiener filter performance studies using real data with different $\langle\mu\rangle$ values

https://indico.cern.ch/event/691318/contributions/3195435/attachments/1743226/2821177/Wiener_filter_studies.pdf

- Studies of the most appropriate energy distribution model to be used in the wiener filter method

https://indico.cern.ch/event/775929/contributions/3225202/attachments/1757770/2850563/Energy_rec_22_11_2018.pdf

https://indico.cern.ch/event/691322/contributions/3230600/attachments/1759226/2853636/E4_studies.pdf

- Introduce the Wiener Filter tool in the athena framework

<https://indico.cern.ch/event/786709/contributions/3303251/attachments/1792372/2920554/Tile06Feb19.pdf>

Major updates:

-- DayaneOliveiraGoncalves- 3 Mar 2019

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